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EP 0463888 A2 EP 0405540 A2 EP 0278395 A2
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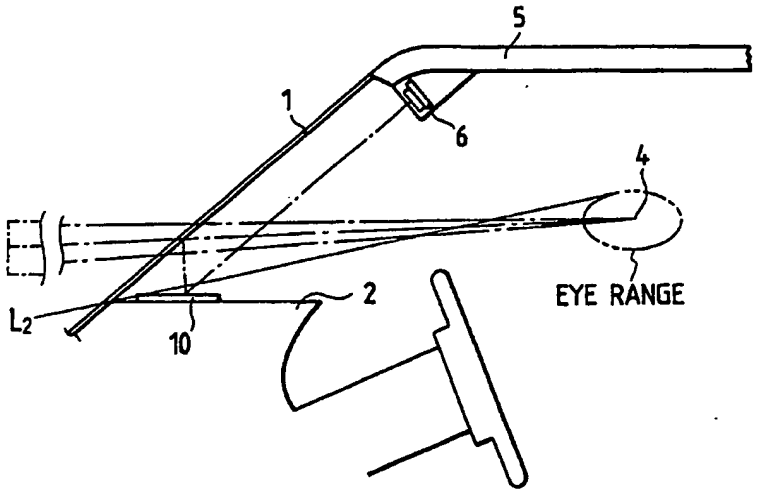
(54) **Head up display system for vehicles**

(57) Light from a display unit 6 mounted on the ceiling 5 of the vehicle is reflected by a non-regular reflecting hologram 10 mounted on the instrument board 2, and reflected by the windshield 1 towards the eyes of a driver on the vehicle. In an alternative embodiment the member 10 is a reflecting board upon which a real image is projected (Fig 3) and the hologram is then optionally present on the windshield (Fig 5).

FIG. 2



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

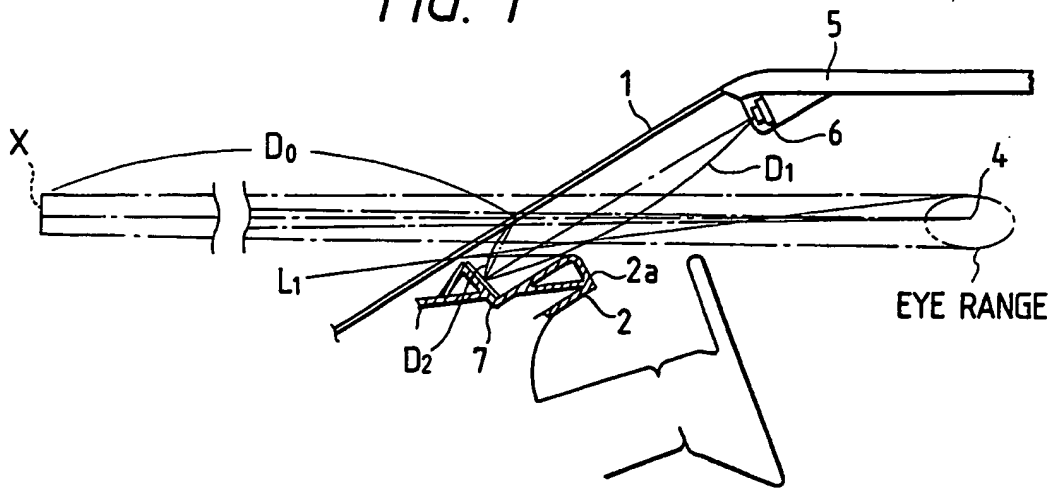


FIG. 2

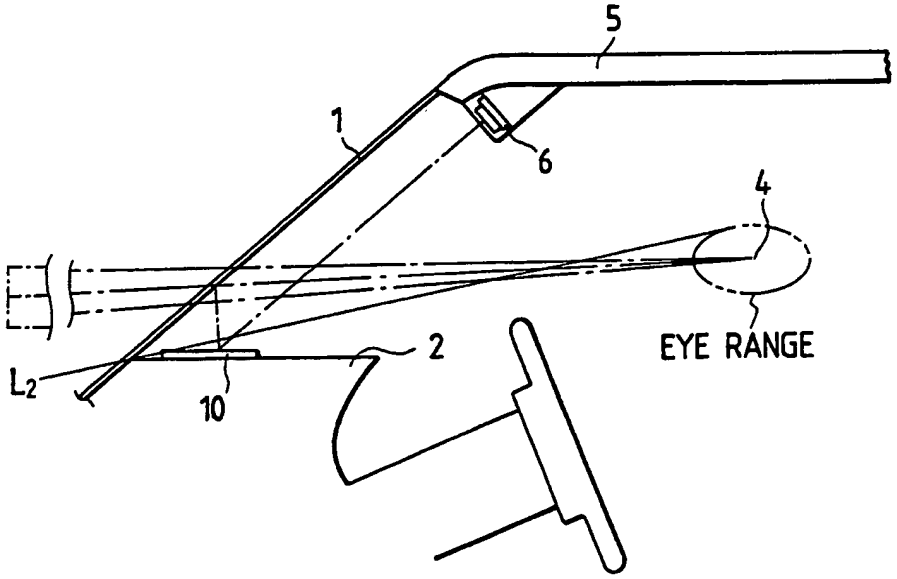


FIG. 3

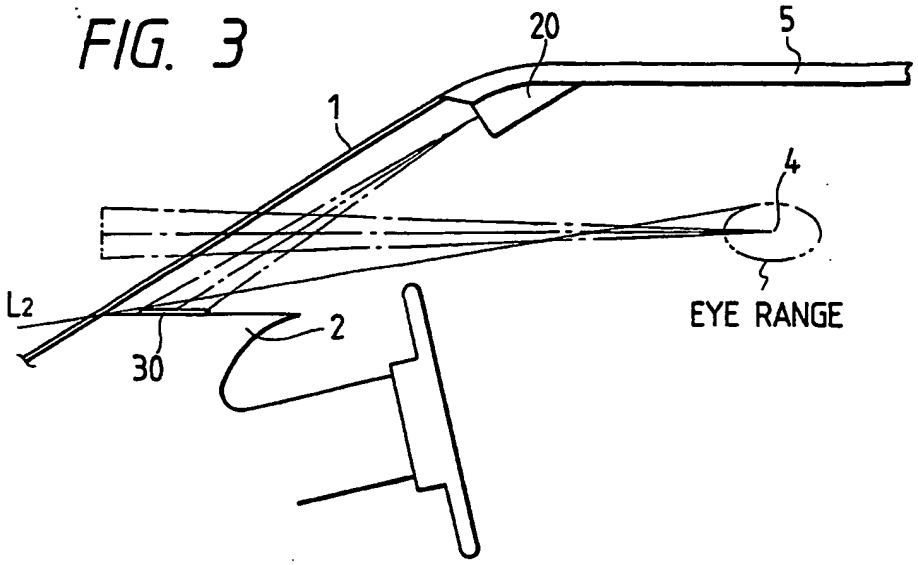


FIG. 4

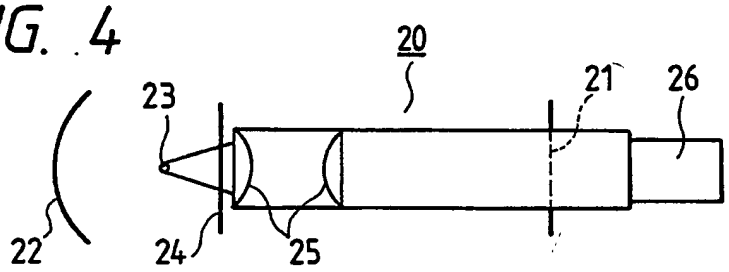
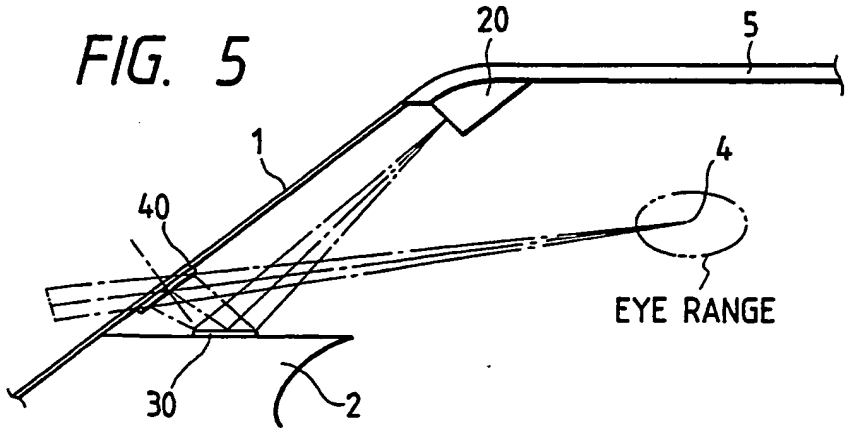


FIG. 5



DISPLAY SYSTEM FOR VEHICLES

This invention relates to a so-called "display system of head-up display type" for a vehicle which is so designed that an image displayed on a display unit adapted to display vehicle data such as a vehicle speed is reflected by a reflecting member such as a reflecting board, and reflected towards the driver by the windshield in front of the driver's seat, thereby to allow the driver to see the virtual image of the display image behind the windshield.

In general, a display system for vehicles is so designed that an image displayed on a display unit can be observed directly by the driver. The display unit is provided on the instrument board on the side of the driver. Hence, the display system suffers from the following difficulties: In order for the driver seeing outside scenes in front of the vehicle to observe an image displayed on the display unit, he must move his eyes or lines of sight wide. In particular when he is driving the vehicle at high speed while seeing distant outside scenes, he must move his eyes or lines of sight wider, and it is rather difficult for him to quickly focus his eyes on the displayed image.

In order to overcome the above-described difficulties, a so-called "head-up type display system" has been proposed and practically used in the art which is designed as follows: That is, the virtual image of an image

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displayed on a display unit is formed behind the windshield (as viewed from the driver's seat), so that the movement of the lines of sight is minimized, and the driver can focus his eyes on the image readily.

One example of the display system is as shown in FIG. 1. That is, as shown in FIG. 1, a display unit 6 for displaying driving data is mounted on the ceiling 5 of the vehicle with its display surface faced towards the front of the vehicle, and in order to reflect display light from the display unit 6, a concave mirror 7 is mounted on the instrument board 2 with its reflecting surface faced towards the display unit 6. Display light from the display unit 6 is reflected by the concave mirror 7, and reflected again by the windshield 1 towards the driver's eyes 4, so that the driver (4) sees the virtual image of an image displayed on the display unit 6 behind the windshield 1 (as viewed from the driver's seat) in such a manner that the virtual image overlaps the outside scene.

In this case, the configuration (or curvature) of the concave mirror 7 is such that the display unit 6 is positioned within the focal length of the concave mirror 7. Owing to the magnifying action of the concave mirror 7, the distance D_0 from the windshield 1 to the virtual image X is longer than the length (D_1 + D_2) of an optical path extended from the windshield 1 through the concave mirror 7 to the display unit 6. Thus, the virtual image is formed at a

sufficiently distant position. The display unit 6 is made up of a fluorescent display tube, an LED display element, or a liquid crystal display element with a back light. In the above-described system, the reflecting member is the concave mirror 7; however, instead of the concave mirror 7, a plane mirror may be employed. In this case, the distance D_0 between the windshield 1 and the virtual image X is equal to the length $(D_1 + D_2)$ of an optical path extended from the windshield 1 through the plane mirror to the display unit 6.

In the case where, as was described above, the display unit 6 is mounted on the vehicle ceiling 5, and the reflecting member (the concave mirror) 7 is mounted on the instrument board 2, it is necessary to prevent external light such as sun light reflected from the reflecting member 7 from reaching the driver's eyes 4; that is, it is necessary to prevent the driver, whose point of sight is on the upper end of an eye range indicated by the two-dot chain line, from seeing the upper edge of the reflecting member 7. For this purpose, a large open cover 2a is installed like a wall on the surface of the instrument board 2 which is closer to the driver than the reflecting member 7, in such a manner that the cover 2a is approximately equal in height to the straight line L_1 connecting the upper end of the eye range and the upper end of the reflecting member 7.

In addition, vehicle conditions such as the position of the display unit 6, the angle of inclination of the

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windshield 1, and the configuration of the upper surface of the instrument board 1 limit the position of installation of the reflecting member 7, so that the system has substantially no freedom in design.

Also, the size of the reflecting member 7 should be determined according to the eye range; that is, the size of the reflecting member should be increased in proportion to the size of the eye range. In order to reduce the size of the reflecting member 7, it is necessary to provide a rotating mechanism which turns the reflecting member 7 according to the position of the point of sight 4 in the eye range, which makes the display system intricate in arrangement as much.

Accordingly, an object of this invention is to provide a display system for a vehicle in which the open cover on the instrument board is reduced in size, and which can be designed with a certain degree of freedom.

Another object of this invention is to provide a display system of head-up display type for a vehicle in which display light from a display unit mounted on the ceiling of the vehicle is reflected by a reflecting member mounted on the instrument board, and reflected by the windshield towards the eyes of a driver on the vehicle, in which the reflecting member is small in size, and the eye range is wide.

The foregoing and other objects of the invention have been achieved by the provision of a display system for a vehicle in which display light from a display unit mounted on the ceiling of the vehicle is reflected by a reflecting member mounted on the instrument board of the vehicle, and reflected by the windshield of the vehicle towards the eyes of a driver on the vehicle, so as to allow the driver to see behind the windshield the virtual image of an image displayed on the display unit; in which, according to the invention, the reflecting member is a non-regular reflection type hologram.

The display system of the invention is designed as described above. Hence, when the power switch of the display unit is turned on, display light from the display unit is reflected by the non-regular reflection type hologram mounted on the instrument board, and reflected by the windshield towards the driver's eyes, so that the driver sees far behind the windshield (in front of the vehicle) the virtual image of an image displayed on the display unit. In the system, the non-regular reflection hologram is employed as the reflecting member, and therefore the position of installation of the reflecting member mounted on the instrument board can be determined with a large degree of freedom.

The foregoing objects of the invention have been achieved by the provision of the following two means:

The first means is a display system for a vehicle in which display light from a display unit mounted on the ceiling of the vehicle is reflected by a reflecting member mounted on the instrument board of the vehicle, and reflected by the windshield of the vehicle towards the eyes of a driver on the vehicle, so as to allow the driver to see behind the windshield the virtual image of an image displayed on the display unit; in which, according to the invention,

the display unit comprises a projector, and

the reflecting member is a reflection type diffusion board,

an image projected by the projector being formed on the diffusion board.

The second means is a display system for a vehicle in which display light from a display unit mounted on the ceiling of the vehicle is reflected by a first reflecting member mounted on the instrument board of the vehicle, and reflected by a second reflecting member on the windshield of the vehicle towards the eyes of a driver on the vehicle, so as to allow the driver to see behind the second reflecting member the virtual image of an image displayed on the display unit; in which, according to the invention,

the display unit comprises a projector,

the first reflecting member is a reflection type diffusion board,

an image projected by the projector being formed on the first diffusion board, and

the second reflecting member is a non-regular reflection type hologram.

The display system is designed as described above. Therefore, when the power switch of the projector is turned on, an image projected by the projector is formed as a real image on the diffusion board through optical lenses and other relevant components - the diffusion board acts as if it were a movie screen. The image formed on the diffusion board is reflected by the windshield towards the driver's eyes, so that the driver is allowed to see far behind the windshield (in front of the vehicle) the virtual image of the real image formed on the diffusion board. In this case, the driver sees the real image on diffusion board through the windshield, and therefore the eye range is considerably large.

In the display system, in which the non-regular reflection type hologram is employed as the second reflecting member on the windshield, the degree of freedom in arranging the first reflecting board on the instrument board can be increased by suitably adjusting the angles of incidence and reflection of the non-regular reflection type hologram.

In the accompanying drawings:

FIG. 1 is a side view showing a conventional system for a vehicle;

FIG. 2 is a side view showing a display system for a vehicle according to this invention;

FIG. 3 is a side view showing another example of a display system for a vehicle, which constitutes a first embodiment of the invention;

FIG. 4 is a sectional view of a projector employed in the display system according to the invention; and

FIG. 5 is a side view showing still another example of the display system, which constitutes a second embodiment of the invention.

One embodiment of this invention will be described with reference to FIG. 2, in which parts corresponding functionally to those which have been described with reference to FIG. 1 are therefore designated by the same reference numerals or characters.

FIG. 2 shows a display system for a vehicle, which constitutes the one embodiment of the invention. As shown in FIG. 1, a display unit 6 for displaying driving data is mounted on the ceiling 5 of the vehicle with its display surface faced towards the instrument board 2. A reflecting member, namely, a non-regular reflection type hologram 10 is mounted in such a manner that its reflecting surface is faced towards the display surface of the display unit and towards the windshield 1 of the vehicle.

The non-regular reflection type hologram 10 is a reflecting board in which the angle of incidence of a light beam applied to the hologram surface is different from the angle of reflection of the light. More specifically, the hologram 10 is formed as follows: In the case where the reflecting function is of a plane mirror, in formation of the hologram an object light beam, and a reference light beam, which are parallel light beams, are applied as laser beams to a hologram dry plate, in such a manner that the beams are different in the angle of incidence, so that interference fringes are recorded thereon. On the other hand, in the case where the reflecting function is of a concave mirror, in formation of the hologram a reference light beam which is a divergent light beam, and an object light beam which is a parallel light beam are applied, as laser beams, to a hologram dry plate, so that interference fringes are recorded thereon. By freely setting the angles of incidence of the object light beam and the reference light beam, the angles of incidence and reflection of the resultant hologram can be selected as desired.

Hence, the non-regular reflection type hologram 10 formed with the position of the display unit 6, the angle of inclination of the windshield 1, the position and angle of the instrument board 2, and the point of sight 4 of the driver taken into account, can be mounted anywhere on the instrument board 2. Therefore, in installation of the

display system, it is unnecessary to deform the instrument board 2, nor to machine it.

When display light from the display unit 6 is applied to the hologram 10 thus installed, the light is reflected at an angle of reflection different from the angle of incident, thus being applied to the windshield 1. The light thus applied is reflected by the windshield 1 towards the driver's eyes 4, so that the driver is allowed to see the virtual image of the image displayed on the display unit 6 far behind the windshield 1 (in front of the vehicle).

As for a countermeasure against external light, it is necessary to prevent the driver from seeing the hologram 10 directly. For this purpose, it is necessary to provide a wall on the instrument board to the height of a straight line L_2 connecting the upper end of the eye range of the driver and the front edge of the hologram 10. However, the wall is much shorter than the conventional open cover.

As was described above, in the display system according to the invention, the non-regular reflection type hologram is employed as the reflecting member provided on the instrument board. Therefore, by adjusting the angles of incidence and reflection of the hologram suitably, the latter can be installed on any instrument board irrespective to its configuration. Therefore, in installation of the display system, it is unnecessary to change the configuration of the instrument board 2, not to machine it. Thus, the

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configuration of the instrument board can be designed with a large degree of freedom; that is, the display system itself can be designed with a large degree of freedom. Furthermore, since the angle of installation of the hologram is not limited, the open cover on the instrument board can be reduced in size.

Other preferred embodiments of this invention will be described with reference to FIGS. 3 through 5, in which parts corresponding functionally to those which have been described with reference to FIG. 1 showing the above-described conventional display system are therefore designated by the same reference numerals or characters.

FIG. 3 shows a display system for a vehicle, which constitutes a first embodiment of the invention. As shown in FIG. 1, a projector 20 for displaying vehicle driving data is mounted on the ceiling of the vehicle in such a manner that it is faced towards the instrument board 2 of the vehicle. A light reflection type diffusion board 30 is mounted on the instrument board 2 in such a manner that its reflecting surface is faced towards the projector 20 and towards the windshield 1 of the vehicle.

The projector 22, as shown in FIG. 4, comprises a display device 21 which is a liquid crystal display element. A light source 23 with a reflecting mirror 22 is provided behind the display device. A cold filter 24 for blocking infrared rays, and a group of condenser lenses 25 are

provided between the light source 23 and the display device 21, so that the output light of the light source 23 is applied to the display device with high efficiency while the rise in temperature of the display device, which is due to the application of light to it, is suppressed as much as possible.

A projecting lens 26 is provided in front of the display device 21. The projecting lens 26 is moved back and forth so that an image displayed on the display device is formed as a real image on a screen provided outside. Therefore, in the display system, the projecting lens 26 is adjusted in position so that an image displayed on the display device 21 is formed on the diffusion board (serving as a screen) 30 mounted on the instrument board 2.

When, in the display system, the power switch of the projector 20 is turned on, the image displayed on the display device 21 is formed as a real image on the diffusion board 30 through the projecting lens 26 of the projector 20. The diffusion board 30 acts as if it were a movie screen, and the image formed on it is reflected by the windshield towards the driver's eyes 4. Hence, the driver (4) sees far behind the windshield 1 the virtual image of the image formed on the diffusion board 30. In this case, the driver sees the virtual image through the windshield 1, and therefore the eye range is considerably large.

As was described above, in the display system, the real image is formed on the diffusion board 30. Therefore, in the display system, unlike the conventional one, it is unnecessary to take the eye range into account in determining the size of the reflecting member; that is, the size of the diffusion board 30 can be reduced to that of the virtual image viewed through the windshield 1. In the invention, the diffusion board 30 is employed as the reflecting member (the mirror being employed in the prior art), therefore the display system is free from problems attributing to external light. However, it is necessary to prevent the driver to see the real image on the diffusion board 30. For this purpose, a wall should be formed on the instrument board 1 to a height of a line L_2 connecting the upper end of the eye range and the front edge of the diffusion board 30.

Another example of the display system, a third embodiment of the invention, will be described with reference to FIG. 5, in which parts corresponding functionally to those which have been described with reference to FIGS. 3 and 4 are therefore designated by the same reference numerals or characters.

The third embodiment of the invention is as shown in FIG. 5, which is different from the above-described second embodiment in that a non-regular reflection type hologram is bonded to the windshield 1. In the second embodiment described above, the image formed on the diffusion board 30

by the projector 20 is reflected by the windshield 1 towards the driver's eyes 4. On the other hand, in the third embodiment, the image formed on the diffusion board 30 by the projector 20 is reflected by the non-regular reflection type hologram 40 towards the driver's eyes 4. The non-regular reflection type hologram is a kind of reflecting board which is so designed that the angle of incident of a light beam applied to the hologram surface is different from the angle of reflection of the light beam. More specifically, the hologram is formed by suitably controlling the conditions of an object light beam and a reference light beam to be applied thereto.

With the non-regular reflection type hologram formed suitably, the diffusion board 30, which is a second reflecting board, can be mounted anywhere on the instrument board 2. In the above-described embodiment, the diffusion board 30 is mounted on the instrument board 2. However, the diffusion board 30 may be provided at other positions if there is no obstacle between the projector 20, the diffusion board 30 and the windshield 1. In addition, in arranging the diffusion board 30 serving as the screen, the angle of the latter can be set more freely. Therefore, the diffusion board 30 can be set in conformance with the configuration of the instrument board 2.

As was described above, in the display system according to the invention, the projector is employed to form

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the real image on the reflecting member which is the diffusion board. Hence, the size of the reflecting member can be reduced to the size of the real image, which makes it possible to miniaturize the reflecting member. Furthermore, since the real image is observed through the windshield, the eye range can be increased, and the open cover on the instrument board can be reduced in size.

In addition, according to the invention, the non-regular reflection type hologram is mounted on the windshield. Therefore, the degree of freedom in arranging the first reflecting board on the instrument board can be increased by suitably adjusting the angles of incidence and reflection of the non-regular reflection type hologram.

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CLAIMS

1. A display system for a vehicle in which display light from a display unit mounted on a ceiling of said vehicle is reflected by a reflecting member mounted on an instrument board of said vehicle, and reflected by a windshield of said vehicle towards the eyes of a driver on said vehicle, so as to allow said driver to see behind the windshield the virtual image of an image displayed on said display unit, the system comprising the improvement wherein said reflecting member is a non-regular reflection type hologram.

2. A display system for a vehicle in which display light from a display unit mounted on a ceiling of said vehicle is reflected by a reflecting member mounted on an instrument board of said vehicle, and reflected by a windshield of said vehicle towards the eyes of a driver on said vehicle, so as to allow said driver to see behind the windshield the virtual image of an image displayed on said display unit, said system comprising the improvement wherein

said display unit comprises a projector,

said reflecting member comprises a reflection type diffusion board, and

an image projected by said projector is formed on said diffusion board.

3. A display system for a vehicle in which display light from a display unit mounted on a ceiling of said

vehicle is reflected by a first reflecting member mounted on an instrument board of said vehicle, and reflected by a second reflecting member on a windshield of said vehicle towards the eyes of a driver on said vehicle, so as to allow said driver to see behind said second reflecting member the virtual image of an image displayed on said display unit, the system comprising the improvement wherein

said display unit comprises a projector,

said first reflecting member is a reflection type diffusion board,

an image projected by said projector being formed on said first diffusion board, and

said second reflecting member is a non-regular reflection type hologram.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

(i) UK Cl (Edition L) G2J (JHU)

(ii) Int Cl (Edition 5) G02B; B60K

Search Examiner
R E HARDY

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
15 SEPTEMBER 1993

Documents considered relevant following a search in respect of claims 1 AND 3

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2240853 A (SMITHS INDUSTRIES) The Figures	1 and 3
X	GB 2197728 A (YAZAKI) Figure 1B and page 5 lines 26-28	1 and 3
X	EP 0479059 A1 (YAZAKI) The Figures; note use of off-axis hologram	1 and 3
X	EP 0463888 A2 (FUJITSU) Figure 1	1 and 3
X	EP 0405540 A2 (HUGHES AIRCRAFT) The Figures	1 and 3
X	EP 0278395 A2 (NIPPONDENSO) The Figures	1 and 3
X	EP 0216692 A2 (SAINT-GOBAIN) Figures 1 and 4 noting angles	1 and 3
X	EP 0066496 A1 (THOMSON CSF) Figure 9	1 and 3
X	US 5035473 A (KUWAYAMA) Figure 1, column 2 lines 7-9 and column 3 lines 16-19	1 and 3
X	US 4967191 A (IINO) Figures 3, 5	1 and 3

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family, corresponding document.

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